Evaluation of animal byproducts for use in modern pet foods: Insights into protein and fat quality


March 2016
Pet Food & Nutrition Science

- Established KSU 2011
- Grain Science & Industry
  - Feed Science & Mgt
- Training: Short courses, Minor, BS, MS, PhD,
- The impact producing safe pet food has on nutrient composition and shelf-life
Process Effects On Nutrition

Effect of Batter Temperature and Retort Time on Thiamine (mg/kg)

- 45 minutes
- 60 minutes
- 90 minutes

Thiamine mg/kg

Batter Temperature °C

- 50
- 60
- 70

Chicken Byproduct
Chicken meal
Low Temp Air Dried
Low Temp & Press Air
Spray Dried Chicken
Spray Dried Egg
Spray Dried Egg White
Spray Dried Egg Yolk

Department of Grain Science and Industry
Does the quality of fat in rendered protein meal matter?
Fat in Rendered Protein Meals

• Fat composition range:
  – 10-25%

• Provide a supplementary source of:
  – Energy
  – Flavor
  – Texture
  – Nutrients (essential fatty acids)

• Issues:
  – Fat oxidation
Food oxidation

- Loss of flavor
- Loss of color
- Reduced nutrient value
- Reduced ingredient functionality
- Accumulation of harmful oxidation compounds

(Addis, 1986).
Oxidation Reaction

Oxidation

Time
Effects of Storage Time on Peroxide Value (PV) and Linoleic Acid (18:2n-6) Concentration in Unstabilized (PB) and Stabilized (PBS) Poultry By-product Meal

(adapted from Kirkland and Fuller, 1971)
### Effects of oxidized fat consumption on puppy growth and fatty acid nutrition

<table>
<thead>
<tr>
<th>Variable</th>
<th>Control</th>
<th>Medium</th>
<th>High</th>
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<tbody>
<tr>
<td>Final wgt, kg</td>
<td>20.43\textsuperscript{a}</td>
<td>19.35\textsuperscript{b}</td>
<td>17.70\textsuperscript{c}</td>
</tr>
<tr>
<td>18:2n-6 mol/100mol</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diet</td>
<td>19.34\textsuperscript{a}</td>
<td>17.81\textsuperscript{b}</td>
<td>15.21\textsuperscript{c}</td>
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<tr>
<td>Plasma</td>
<td>24.00\textsuperscript{a}</td>
<td>23.44\textsuperscript{a}</td>
<td>21.92\textsuperscript{b}</td>
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<tr>
<td>Bone</td>
<td>13.71\textsuperscript{a}</td>
<td>11.46\textsuperscript{b}</td>
<td>9.29\textsuperscript{c}</td>
</tr>
<tr>
<td>Serum Vit E, ppm</td>
<td>2.2\textsuperscript{a}</td>
<td>1.3\textsuperscript{b}</td>
<td>0.52\textsuperscript{c}</td>
</tr>
</tbody>
</table>

- Altered immune function
- Impaired rate of bone formation

Turek et al., 2002
How is Pet food Shelf-Life Defined?

• The time it takes for the food to reach a point at which it becomes unacceptable
  – Offensive odor to the pet owner
  – Buildup of harmful toxins
  – Dog or cat rejects the food
Toward a Solution: Emerging Issues
NRA, 23Oct2012

• In rendered protein meals there is a need
  – To establish a baseline understanding regarding methods of analysis for oxidation
  – To dig deeper regarding methods of preservation
    • Application systems
    • Preservative mixes
    • Product carry-through
  – To develop rapid and reliable testing methods for commerce
  – To better understand ingredient impact on food shelf-life
Evaluation of Oxidation
# Comparison of Oxidation Measures

(mean ± standard deviation)

<table>
<thead>
<tr>
<th>Supplier/Source</th>
<th>BMBM</th>
<th>CBPM</th>
<th>TM*</th>
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<tbody>
<tr>
<td>N=</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>PV Lab 1 (mEq/kg)</td>
<td>16.85&lt;sup&gt;b&lt;/sup&gt; ± 24.671&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4.00&lt;sup&gt;b&lt;/sup&gt; ± 1.857&lt;sup&gt;b&lt;/sup&gt;</td>
<td>169.35&lt;sup&gt;a&lt;/sup&gt; ± 167.973&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>PV Lab 2 (mEq/kg)</td>
<td>5.25&lt;sup&gt;a&lt;/sup&gt; ± 0.269&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.05&lt;sup&gt;b&lt;/sup&gt; ± 0.066&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.12&lt;sup&gt;d&lt;/sup&gt; ± 0.145&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>PV SafTest (mEq/kg)</td>
<td>21.64&lt;sup&gt;b&lt;/sup&gt; ± 31.086&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.39&lt;sup&gt;b&lt;/sup&gt; ± 0.736&lt;sup&gt;b&lt;/sup&gt;</td>
<td>127.93&lt;sup&gt;a&lt;/sup&gt; ± 159.896&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Anisidine Value</td>
<td>3.57&lt;sup&gt;abc&lt;/sup&gt; ± 2.877&lt;sup&gt;abc&lt;/sup&gt;</td>
<td>0.57&lt;sup&gt;bc&lt;/sup&gt; ± 0.912&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>5.92&lt;sup&gt;a&lt;/sup&gt; ± 3.058&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>TBARS (mg MDA eq/g oil)</td>
<td>0.037&lt;sup&gt;e&lt;/sup&gt; ± 0.0061&lt;sup&gt;e&lt;/sup&gt;</td>
<td>0.044&lt;sup&gt;d&lt;/sup&gt; ± 0.0072&lt;sup&gt;d&lt;/sup&gt;</td>
<td>0.053&lt;sup&gt;c&lt;/sup&gt; ± 0.0030&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>abcde</sup> Means within a row with unlike superscripts differ P ≤ 0.05.

* Turkey meal was excluded from statistical analysis due to lack of replicate samples.
Gas Chromatography-Mass Spectrometry

- Hexanal
- Heptanal
- Octanal
- Nonanal
- Decanal

Peroxide (meq/kg) & Anisidine Value

Aldehydes (ppb)
Shelf Life – Ambient Storage (23°C, 25% RH)

Peroxide Value (meq/kg) vs. Time (Weeks)

- PV - BMBM-B
- PV - BMBM-C
- PV - CBPM-C
- PV - TM
- AV - BMBM-B
- AV - BMBM-C
- AV - CBPM-C
- AV - TM

Anisidine Value vs. Time (Weeks)

- PV - BMBM-B
- PV - BMBM-C
- PV - CBPM-C
- PV - TM
- AV - BMBM-B
- AV - BMBM-C
- AV - CBPM-C
- AV - TM
Shelf Life – Accelerated Storage (36°C, 52% RH)

![Graph showing the changes in Peroxide Value and Anisidine Value over time for different treatments.](image-url)
Particle size analysis of beef meat and bone meal (BMBM) and chicken byproduct meal (CBPM) main effect least square means

<table>
<thead>
<tr>
<th></th>
<th>BMBM</th>
<th>CBPM</th>
<th>SEM</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particle Size, Dgw¹</td>
<td>492.3</td>
<td>511.9</td>
<td>16.2</td>
<td>0.40</td>
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<tr>
<td>Particles / Gram</td>
<td>37460</td>
<td>20221</td>
<td>2464.6</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Surface Area, cm²/gram</td>
<td>112.6</td>
<td>102.1</td>
<td>3.8</td>
<td>0.06</td>
</tr>
</tbody>
</table>

¹Geometric mean diameter
Evaluation of the Use of Oxidized Rendered Protein Meal in an Extruded Pet Food
Materials & Methods

[Diagram showing the flow of materials and methods]

Kansas State University | Department of Grain Science and Industry
Materials & Methods - BMBM

![Graph showing PV and AV over time for BU, BT, and BE samples.](Image)
Materials & Methods - CBPM

![Graph showing PV, meq/kg over time (days) for different conditions: CU-PV, CT-PV, CE-PV, CU-AV, CT-AV, CE-AV.](image)

- **PV, meq/kg**
- **Time (Days)**
- **AV**

**Legend:**
- CU-PV
- CT-PV
- CE-PV
- CU-AV
- CT-AV
- CE-AV

**Note:**
- The graph illustrates the changes in PV over time for different conditions, with markers indicating specific time points for each condition.

**Source:**
- Kansas State University, Department of Grain Science and Industry
**Materials & Methods**

- **Model cat food diet**

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Diet, %</th>
<th>Diet %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chicken By-Product Meal</td>
<td>37.80</td>
<td>-</td>
</tr>
<tr>
<td>Meat and Bone Meal</td>
<td>-</td>
<td>51.37</td>
</tr>
<tr>
<td>Rice, Brewers</td>
<td>18.92</td>
<td>14.38</td>
</tr>
<tr>
<td>Corn</td>
<td>18.92</td>
<td>14.38</td>
</tr>
<tr>
<td>Wheat</td>
<td>18.92</td>
<td>14.38</td>
</tr>
<tr>
<td>Beet Pulp</td>
<td>4.00</td>
<td>4.00</td>
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<tr>
<td>Potassium Chloride</td>
<td>0.40</td>
<td>0.40</td>
</tr>
<tr>
<td>Monosodium Phosphate</td>
<td>-</td>
<td>0.25</td>
</tr>
<tr>
<td>Salt</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>Choline Chloride, 60% Dry</td>
<td>0.20</td>
<td>0.20</td>
</tr>
<tr>
<td>Vitamin Premix (Kansas)</td>
<td>0.15</td>
<td>0.15</td>
</tr>
<tr>
<td>Trace Mineral Premix (Kansas)</td>
<td>0.10</td>
<td>0.10</td>
</tr>
<tr>
<td>DL Methionine</td>
<td>0.10</td>
<td>-</td>
</tr>
<tr>
<td>Taurine</td>
<td>-</td>
<td>0.05</td>
</tr>
<tr>
<td><strong>Ingredient Total</strong></td>
<td>100.00</td>
<td>100.00</td>
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</table>
Before and After Pet Food Processing
Oxidized BMBM

Prior To Extrusion

Post Extrusion

PV (meq/kg)

AV

PV - Control

PV - Mixed Tocopherols

PV - Ethoxyquin

AV - Control

AV - Mixed Tocopherols

AV - Ethoxyquin

Kansas State University | Department of Grain Science and Industry
Before and After Pet Food Processing
Oxidized CBPM

PV (meq/kg)

0.00 10.00 20.00 30.00 40.00 50.00 60.00 70.00 80.00 90.00 100.00

PV - Control
PV - Mixed Tocopherols
PV - Ethoxyquin

AV - Control
AV - Mixed Tocopherols
AV - Ethoxyquin

Prior To Extrusion
Post Extrusion
Shelf Life

• 3 kg of pet food/treatment in Ziploc bags
• Accelerated: 40°C; 70% RH
• Ambient: 22°C; 45% RH (ongoing)
Accelerated Shelf Life of Pet Food Produced with Oxidized BMBM (40°C; 70% RH)

PV, meq/kg

AV

PV - Control
PV - Mixed Tocopherols
PV - Ethoxyquin
AV - Control
AV - Mixed Tocopherols
AV - Ethoxyquin

Time (Weeks)

0 3 6 12 18

0.00 5.00 10.00 15.00 20.00
Accelerated Shelf Life of Pet Food Produced with Oxidized CBPM (40°C; 70% RH)
Gas Chromatography – Mass Spectrometry (BMBM - Kibble)

Total Aldehydes (ppb)

- Unpreserved
- Mixed Tocopherols
- Ethoxyquin

Time (Weeks)

- 0
- 3
- 6
- 12
- 18

Total Aldehydes (ppb):

- 0: Unpreserved (6000 ppm), Mixed Tocopherols (10000 ppm), Ethoxyquin (12000 ppm)
- 3: Unpreserved (6000 ppm), Mixed Tocopherols (4000 ppm), Ethoxyquin (2000 ppm)
- 6: Unpreserved (6000 ppm), Mixed Tocopherols (4000 ppm), Ethoxyquin (2000 ppm)
- 12: Unpreserved (6000 ppm), Mixed Tocopherols (4000 ppm), Ethoxyquin (2000 ppm)
- 18: Unpreserved (6000 ppm), Mixed Tocopherols (4000 ppm), Ethoxyquin (2000 ppm)

Kansas State University
Department of Grain Science and Industry
Gas Chromatography – Mass Spectrometry (CBPM - Kibble)

- Unpreserved
- Mixed Tocopherols
- Ethoxyquin

**Total Aldehydes (ppb)**

<table>
<thead>
<tr>
<th>Time (Weeks)</th>
<th>0</th>
<th>3</th>
<th>6</th>
<th>12</th>
<th>18</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unpreserved</td>
<td>1200</td>
<td>2200</td>
<td>3800</td>
<td>7600</td>
<td>7600</td>
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<tr>
<td>Mixed Tocopherols</td>
<td>500</td>
<td>1000</td>
<td>1500</td>
<td>2000</td>
<td>3500</td>
</tr>
<tr>
<td>Ethoxyquin</td>
<td>200</td>
<td>300</td>
<td>400</td>
<td>600</td>
<td>400</td>
</tr>
</tbody>
</table>
Conclusions

• PV was inconsistent and not descriptive of quality.

• The ingredient oxidation levels were diluted by food production, and their oxidation may not completely account for later food product deterioration.

• Oxidation measures (e.g. PV) don’t match with consumer sensory factors identifying foods as rancid and need to be recalibrated.
# Mean intensity scores of aroma attributes for CBPM samples

<table>
<thead>
<tr>
<th>Sample</th>
<th>Storage time (month)</th>
<th>Oxidized Oil</th>
<th>Stale</th>
<th>Cardboard\textsuperscript{NS}</th>
<th>Rancid</th>
</tr>
</thead>
<tbody>
<tr>
<td>CBPM-O</td>
<td>0</td>
<td>2.29 c</td>
<td>2.38 bcd</td>
<td>2.75</td>
<td>0.33 c</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>2.50 bc</td>
<td>2.33 bcd</td>
<td>2.54</td>
<td>0.33 c</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>2.88 b</td>
<td>2.50 ab</td>
<td>2.54</td>
<td>1.17 b</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>2.50 bc</td>
<td>2.33 bcd</td>
<td>2.58</td>
<td>1.00 bc</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>4.13 a</td>
<td>2.75 a</td>
<td>2.83</td>
<td>4.21 a</td>
</tr>
<tr>
<td>CBPM-MT</td>
<td>0</td>
<td>2.38 c</td>
<td>2.25 bcde</td>
<td>2.54</td>
<td>0.63 bc</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>2.38 c</td>
<td>2.46 bc</td>
<td>2.46</td>
<td>0.33 c</td>
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<tr>
<td></td>
<td>6</td>
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<td>2.17 de</td>
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<td>0.29 c</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>2.50 bc</td>
<td>2.21 cde</td>
<td>2.42</td>
<td>0.71 bc</td>
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<tr>
<td>CBPM-ET</td>
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<td>2.00 e</td>
<td>2.33</td>
<td>0.46 bc</td>
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<tr>
<td></td>
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<td>2.13 c</td>
<td>2.29 bcd</td>
<td>2.38</td>
<td>0.58 bc</td>
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<tr>
<td></td>
<td>9</td>
<td>2.13 c</td>
<td>2.17 de</td>
<td>2.63</td>
<td>0.50 bc</td>
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<tr>
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<td>12</td>
<td>2.17 c</td>
<td>2.21 cde</td>
<td>2.21</td>
<td>0.88 bc</td>
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Mean intensity scores of aroma attributes for BMBM samples

<table>
<thead>
<tr>
<th>Sample</th>
<th>Storage Time (month)</th>
<th>Aroma</th>
<th></th>
<th></th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Oxidized Oil</td>
<td>Stale</td>
<td>Cardboard</td>
<td>Rancid</td>
</tr>
<tr>
<td>BMBM-O</td>
<td>0</td>
<td>2.29 fg</td>
<td>2.04 e</td>
<td>2.50 c</td>
<td>0.46 def</td>
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<td></td>
<td>3</td>
<td>2.42 def</td>
<td>2.25 cde</td>
<td>2.58 bc</td>
<td>0.08 fg</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>2.00 g</td>
<td>2.04 e</td>
<td>2.58 bc</td>
<td>0.33 efg</td>
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<td>9</td>
<td>2.46 cdef</td>
<td>2.38 bcd</td>
<td>2.67 bc</td>
<td>1.04 bc</td>
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<tr>
<td></td>
<td>12</td>
<td>2.63 bcde</td>
<td>2.42 bc</td>
<td>2.67 bc</td>
<td>0.71 cde</td>
</tr>
<tr>
<td>BMBM-MT</td>
<td>0</td>
<td>2.29 fg</td>
<td>2.13 de</td>
<td>2.54 c</td>
<td>0.17 fg</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>2.29 fg</td>
<td>2.29 bcde</td>
<td>2.71 bc</td>
<td>0.17 fg</td>
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<td></td>
<td>6</td>
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<td>2.29 bcde</td>
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<td>3.21 a</td>
<td>2.54 b</td>
<td>2.79 b</td>
<td>1.63 a</td>
</tr>
<tr>
<td>BMBM-ET</td>
<td>0</td>
<td>2.33 ef</td>
<td>2.42 bc</td>
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<td>0.08 fg</td>
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<td>2.58 bc</td>
<td>1.33 ab</td>
</tr>
</tbody>
</table>
External preference mapping of CBPM-O samples from 5 different time points and average overall liking from 106 pet owners. Black dots represent samples from specific time point; red dots represent sensory attributes.
External preference mapping of BMBM-O samples from 5 different time points and average overall liking from 106 pet owners. Black dots represent samples from specific time points; red dots represent sensory attributes.